People get ready.
Curtis Mayfield (1942–1999)

CLIMATE CHANGE

Health Scenarios for a Warming World

A large fraction of emissions of carbon dioxide (CO_2)—the greenhouse gas produced by human activities in the greatest quantities—is long lived in the atmosphere, so decisions made today to continue adding CO_2 into the atmosphere may lock future generations into a range of human health and environmental impacts, some of which could become very severe, according to a committee of the National Research Council (NRC). In a report that looks at the short- and long-term effects of the stabilization of Earth's temperature, the NRC committee quantifies, as much as possible, the outcomes of different stabilization targets for the planet, with a focus on the United States.[1]

The report synthesizes global warming science in myriad fields along with research on the potential impacts for human health and other arenas. Then the committee adds a twist: rather than expressing climate goals in terms of stabilizing atmospheric concentrations of CO_2, the authors assess such goals using global mean temperature change as the primary metric. The twist allows the authors to link the potential impacts from climate change more directly to temperature change.

Research to date suggests many potential impacts can be directly linked to temperature, or to things that can be themselves linked to temperature (e.g., precipitation), although some (e.g., ocean acidification) are linked directly to CO_2 concentration, says Damon Matthews of Concordia University, a report coauthor. "But in this report we were . . . noting the additional impacts you would expect for a given degree in global temperature change," says Katharine Hayhoe of Texas Tech University, another coauthor. Given the anticipated impacts for anywhere from a 1- to 5-°C global temperature increase, the panel "worked backwards and said, 'If we picked a temperature target based on a risk that is acceptable [to society], then what does that imply regarding the CO_2 levels we must aim for?'" according to Hayhoe.

Things shifted for climate change researchers about five years ago, when climate models began to factor in the carbon cycle, making it easier to include specific CO_2 emissions scenarios and link them to temperature, says Matthews. In 2009 Matthews and colleagues described the framework for linking the temperature response to carbon emissions, a construct known as the carbon climate response.[2] The carbon climate response—the ratio of temperature change to cumulative carbon emissions—"allows CO_2-induced global mean temperature change to be inferred directly from cumulative carbon emissions," Matthews et al. wrote.[2] Three other papers published the same year[3–5] proposed a similar framework and demonstrated "a remarkably consistent temperature response to a given level of cumulative carbon emissions," the NRC report notes.[1]

The NRC report discusses three main types of health-related stress expected from rising average temperatures: illness and infectious diseases carried by animal hosts and mosquitoes and other vectors, heat-related illness and deaths, and health problems due to air pollution (e.g., related to increased ozone formation) and water contamination (e.g., related to more frequent heavy downpours).

In one discussion, the report summarizes research on a 1995 Chicago heat wave that resulted in 692 heat-related deaths within the city[6] and extrapolates to predict how many heat waves and deaths might occur with each degree of temperature rise. For instance, under a 2°C change in global mean temperature, annual average mortality rates are projected to equal those of 1995, whereas under a 4°C change in global mean temperature, annual average mortality is projected to be twice 1995 levels, and 1995-like heat waves are predicted to occur as frequently as three times per year.[7]

Yet quantifying the impact on human health per degree of global temperature change is difficult, and must take into account many confounding factors including behavior, says Christopher Portier, now director of the National Center for Environmental Health and the Agency for Toxic Substances and Disease Registry. In his former position as senior advisor at the National Institute of Environmental Health Sciences, Portier led a federal working group that released a report on 11 categories of disease and other health consequences that may occur due to climate change.[8] That report highlighted a huge need for research to better understand the link between global warming and human health effects, Portier says.

The NRC report was released a few days before Senate majority leader Harry Reid (D–NV) announced there were not enough votes in support of climate change legislation, meaning Congress won't pass a climate change bill in 2010. Tim Profeta, director of the Nicholas Institute for Environmental Policy Solutions at Duke University, says he read the NRC report the same day that climate legislation was failing in the Senate. "That created quite a juxtaposition," he says, "showing us both the challenges we have before us and the amount of work that we have to get done."

Selected Potential Impacts[1]
(per degree global temperature increase)

1–2°C of Warming
FIRE
- 200–400% increase in area burned per degrees in parts of western United States

1–4°C of Warming
RAIN
- 5–10% less rainfall per degree in Mediterranean, SW North America, southern Africa dry seasons
- 5–10% more rainfall per degree in Alaska and other high-latitude Northern Hemisphere areas
- 3–10% more heavy rain per degree in most land areas

RIVERS
- 5–10% less streamflow per degree in some river basins, including the Arkansas and Rio Grande

FOOD
- 5–15% reduced yield of U.S. corn, African corn, and Indian wheat per degree

SEA ICE
- 15% reduction in annual average Arctic sea ice area per degree

3°C of Warming
COASTS
- Loss of about 250,000 km² of wet- and drylands
- Millions more people at risk of coastal flooding

TEMPERATURE EXTREMES
- 9 of 10 summer seasons are expected to be warmer than all but 1 summer of 20 in the last decades of the 20th century over nearly all land areas

4°C of Warming
TEMPERATURE EXTREMES
- About 9 out of 10 summers warmer than the warmest ever experienced during the last decades of the 20th century over nearly all land areas

5°C of Warming
FOOD
- Yield losses in most regions and potential doubling of global grain prices

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INDUSTRY ISSUES

Pharmaceutical Factories as a Source of Drugs in Water

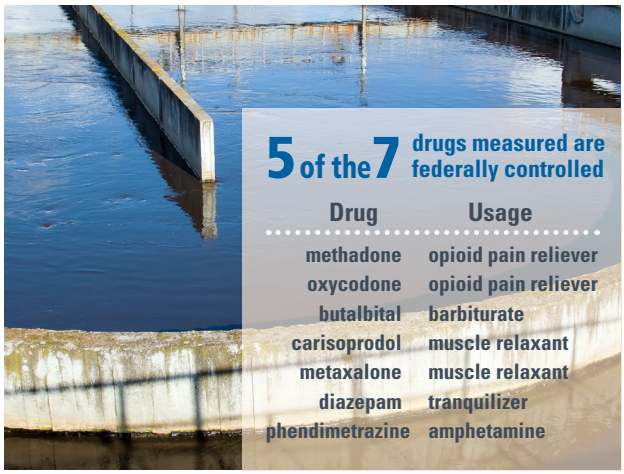
Low levels of active pharmaceutical ingredients (APIs) turning up in natural waterways and drinking water supplies are coming under increasing scrutiny for their potential health effects on people and wildlife. Human waste has been identified as the main source of these pharmaceuticals, along with the common practice of flushing unused medications down the toilet. Now, a new study by the U.S. Geological Survey (USGS) highlights a largely overlooked contributor: pharmaceutical manufacturers.[1] Effluent from two U.S. wastewater treatment plants that received discharge from pharmaceutical manufacturing facilities had levels of seven APIs that were 10–1,000 times higher than effluent from plants that received no such waste.

Between 2004 and 2009, USGS researchers sampled effluent and receiving water downstream from three wastewater treatment plants in New York State. Two of the plants received about 20% of their waste from pharmaceutical manufacturing facilities; the other received none. Researchers also collected effluent samples from 23 treatment plants around the nation that did not serve pharmaceutical manufacturers.

The researchers analyzed the samples for seven APIs (see box). In effluent from the two treatment plants serving pharmaceutical manufacturers, median concentrations of the most common APIs ranged from 2 to 400 µg/L. The researchers also found surprisingly high maximum concentrations of 1,700 µg/L for oxycodone and 3,800 µg/L for metaxalone. Moreover, low levels of two of the APIs turned up in a drinking water reservoir 30 km downstream from one plant. By contrast, in effluent from treatment plants with no pharmaceutical manufacturers among their clientele, concentrations of individual APIs rarely exceeded 1 µg/L, a figure that aligns with previous findings from treatment plant effluent in the United States and Europe.[2,3]

According to the authors, the USGS study is the first to directly link high concentrations of APIs in water to pharmaceutical manufacturers in the United States. This study follows a 2007 report of unprecedentedly high levels of API residues in effluent from an Indian treatment plant serving some 90 pharmaceutical manufacturers.[4] The antibiotic ciprofloxacin occurred at levels up to 31,000 µg/L—more concentrated than the maximum therapeutic levels in human plasma.

Scientists have assumed those findings wouldn't translate to the Western world, in part because the high market value of pharmaceutical products presumably motivates manufacturers to recover as much as possible and keep discharges to a minimum. "The conventional wisdom when the India paper came out was, 'Well, that just couldn't happen here.' . . . And in fact, it did happen," says Patrick J. Phillips, the present study's lead author. He adds that it remains to be seen whether the API levels his team found apply to effluents from other U.S. pharmaceutical manufacturers.



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The human health effects of waterborne APIs are largely unknown. Phillips points out that high concentrations of some APIs would raise greater concern than others, such as antibiotics that may promote drug resistance in bacteria. Of the seven drugs his team measured, five are federally controlled substances,[5] and a quick calculation suggests that for oxycodone, for instance, a person would need to drink just 1.4 L of effluent containing the maximum concentration detected to ingest the lowest commercial dose of the drug.[6]

But of course, people usually do not drink effluent, and while praising the study, Christian Daughton, chief of the Environmental Chemistry Branch at the U.S. Environmental Protection Agency (EPA), points out that what really matters for human health are API levels in finished drinking water. So far these have typically been found only at minute nanogram-per-liter concentrations. "There's very little evidence that just about any chemical at that level has an effect on humans," Daughton says. Of greater concern is the potential effect on aquatic life, since even low levels of antidepressants and endocrine disruptors commonly found in sewage can profoundly affect fish and other organisms.[7,8]

The USGS findings also raise the question of transparency. U.S. manufacturers have no obligation to disclose what APIs they produce or discharge, so Phillips's team relied on a time-consuming "forensic" approach: they chose the seven compounds for analysis only after noticing unusual chromatograph spikes in water samples, and then painstakingly developed detection methods for each one. Phillips says that since he's shown that APIs from factories can get through treatment plants and into reservoirs, manufacturers should share more information with environmental monitors.

In response to the study, the Pharmaceutical Research and Manufacturers of America asserts that factories comply with environmental regulations and that APIs detected in surface waters "come primarily from patient use." The pharmaceutical company Pfizer comments, "Previous studies have indicated . . . that the contribution from manufacturing operations is negligible. We look forward to subsequent work in this area to further understand the issue."

Attention to the patient side of the equation has been gaining momentum. Take-back programs are cropping up across the nation as a way for consumers to safely dispose of unused medications.[9] And the U.S. Senate's Special Committee on Aging held a hearing on the subject in June. Committee chair Herb Kohl (D–WI) called for more take-back and waste-reduction programs to be implemented and for harmonization of contradictory federal guidelines on proper pharmaceutical disposal. Opening the hearing, he echoed the sentiments of many scientists when he stated, "While we don't know yet what impact this has on humans, we can all agree that it's disturbing to think about leftover drugs tainting our drinking water."[10]

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LAWS, REGULATIONS, AND POLICY

Genetically Engineered Salmon on the FDA's Table

AquaBounty Technologies

This fall the U.S. Food and Drug Administration (FDA) is expected to decide on the first-ever genetically engineered (GE) nonplant food source for human consumption—a proposal by Massachusetts-based AquaBounty to sell sterile eggs of a salmon with genetic material from the Chinook salmon and the ocean pout inserted for fast growth. Growers who buy the eggs can raise market-size salmon in 16–18 months instead of three years.[1] But consumer groups have questioned what they call a secretive FDA process for evaluating foods developed from GE animals.

The rubric for regulating genetically modified animals differs from that used for crops, notes Greg Jaffe, biotechnology project director at the Center for Science in the Public Interest, a nonprofit consumer advocacy group in Washington, DC. "They use the animal-drug rubric because that's the legal construct they have," Jaffe says. "But it's like jamming a square peg in a round hole" because there's more secrecy in developing drugs than for foods. Still, he says, "it's better than what we have on the crop side."

Using the same legal basis as for animal drugs—and unlike the process for crops—the FDA's process for animals is mandatory and requires approval before going to market. But although the FDA may provide a public-comment opportunity in conjunction with the Advisory Panel meeting it calls for each modified animal it reviews, Jaffe says the agency can issue its findings without providing all the underlying data, which requires consent from the company. "The FDA doesn't control completely the transparency of its regulatory process," Jaffe says; for that reason, he says, "I don't think it goes far enough."

The FDA process is outlined in a document called Guidance for Industry (GFI) 187,[2] released in January 2009. According to Larisa Rudenko, senior adviser for biotechnology at the FDA Center for Veterinary Medicine, GFI 187 clarifies the agency's statutory authority for regulating GE animals and lays out recommendations for how producers of those animals could submit data to the agency for review.

As described in GFI 187,[2] the FDA requires a proposed GE change be stable for at least two noncontiguous generations sampled across a minimum span of three generations. The agency examines the health of the animal and the safety of any products from those animals that are consumed by humans, and assesses risk to the environment given the description of how the animal will be raised. The FDA uses a risk-based assessment of potential hazards and likelihood of harm.

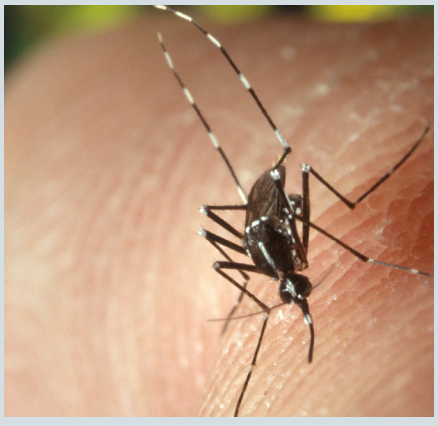
Assessments are made on a case-by-case basis, emphasizes Rudenko. "We wanted to write a guidance at a sufficiently high altitude" that it would apply to all GE animals. She adds that "the FDA neither supports nor opposes [biotechnology]. We're making a science-based decision."

The Beat

by Erin E. Dooley

Asian Tiger Mosquitoes Roar Indoors

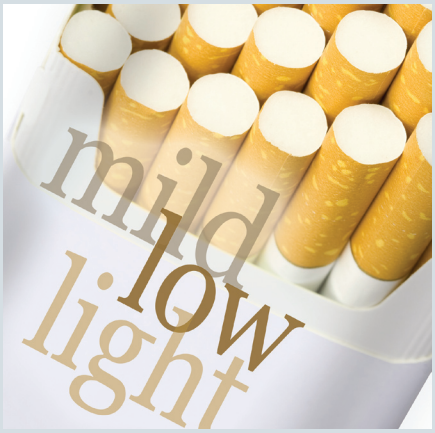
A new study from Penang Island, Malaysia, finds that the Asian tiger mosquito (*Aedes albopictus*) is adapting to indoor environments, a factor that could increase vector–host contacts and the population density of the vector, thereby potentially increasing the diseases spread by this vector.[1] The study showed the indoor-adapted mosquitoes had a longer lifespan and completed more reproductive cycles than outdoor-breeding mosquitoes. Asian tiger mosquitoes spread dengue viruses, chikungunya, yellow fever, and encephalitis viruses. These mosquitoes are linked to a rare U.S. outbreak of dengue fever in May 2009.



CDC/James Gathany; Joseph Tart/EHP

New Cigarette Label Regulations Take Effect

Although consumers may assume cigarettes labeled *light*, *low*, or *mild* are healthier than regular cigarettes, there is no substantial scientific evidence that proves low-tar cigarettes cause fewer smoking-related health effects. Since 22 July 2010 those labeling terms have become off limits to cigarettes distributed in the United States under the Family Smoking Prevention and Tobacco Control Act of 2009.[2] By July 2011 the U.S. FDA will establish requirements for large cigarette health warnings on labels, including color graphics depicting the adverse health effects of smoking, says FDA representative Kathleen Quinn.



Light-Colored Roofs Cool Cities

Roofs and pavements cover 50–65% of urban areas. Using a detailed NASA global land surface model, researchers have found that light-colored rooftops and road surfaces can offset the heating effect of up to two years of current global CO_2 emissions.[3]

Sterile AquAdvantage® eggs (opposite) will be sold to growers and yield only female fish (shown in rear, below, compared with a nontransgenic Atlantic salmon of the same age).

AquaBounty Technologies

The divide over foods derived from GE animals has remained consistent for years, notes Marion Nestle, a professor in the Department of Nutrition, Food Studies, and Public Health at New York University. Compared with agricultural crops, she says, issues surrounding GE animals are mainly environmental, including concern that the animals could escape and breed with wild populations.

In the case of the AquaBounty AquAdvantage® salmon, only sterile female eggs will be sold to growers, and the fish will be grown in contained inland systems, according to the company's application to the FDA. The main environmental concerns with the AquAdvantage salmon involve the possible impact on wild salmon, specifically the possibility that some eggs might not be sterile and end up being fertilized, and that the transgenic salmon might thus get established in marine ecosystems, where they could influence wild relatives, says Calestous Juma, director of the Science, Technology and Globalization Project at Harvard University.

"Though the chance of such events occurring remains minimal, it will be essential to monitor the technology's use," Juma says. Indeed, he adds, monitoring will address the main challenge of GE animals: how to generate trust in the new technology.

Given the depletion of fisheries stocks worldwide, says Juma, the AquAdvantage salmon could represent a significant way to increase protein production while reducing pressure on natural fish stocks. He calls it "one of the few examples where a new technology demonstrates clear human–environmental benefits," with potential for improving food security globally. He adds that this technology could help developing nations bypass a growth stage of aquaculture involving heavy use of antibiotics and other chemicals, and instead leapfrog to more ecologically sound aquaculture.

"The public will see this has been a very thorough, careful evaluation," says Rudenko. "We're committed to making this [process] as transparent as we can." She adds, "This is a mandatory approval process—what's flexible is how one presents the data."

As for what's next for the AquAdvantage salmon, a representative for the company who requested to remain anonymous says AquaBounty received notification this summer that the agency had the bulk of the information needed for a decision.

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The increased reflectivity of these surfaces allows entire buildings and surrounding areas to maintain cooler temperatures. The result: less energy is required to keep indoor temperatures comfortable. The study looked at the effect of changing urban surfaces to cooler colors, not just bright white—a color that may not appeal to some homeowners. In July 2010, DOE Secretary Steven Chu announced a federal initiative under President Obama's Executive Order on Sustainability to implement cool roof technologies on government facilities.[4]

Stronger Ozone Layer Protection May Reduce Cataract Incidence

A new EPA report indicates stricter 1997 amendments to the Montreal Protocol may be paying off.[5] The report predicts more than 22 million additional cataract cases may be avoided in Americans born between 1985 and 2100 thanks to successful ongoing efforts to repair the Earth's ozone layer. The EPA report used the recently updated Atmospheric and Health Effects Framework model to predict avoided cataract cases. According to the U.S. EPA, the ozone layer is expected to recover to pre-1980 levels by 2065.

Hotter Nights May Affect Asian Rice Crops

A six-year study, the first of its kind using real-world data, shows that hotter nights affect rice productivity, and that with continued climate change the effect may worsen as this century progresses.[6] The authors found increased nighttime temperatures affected a key stage in ripening known as grain filling—perhaps because energy the rice usually spent ripening was diverted to increased respiration. They predict the scenario may get worse as daytime temperatures increase to certain predicted levels, which also may restrict the growth cycle of rice plants.

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